University of Tripoli – Faculty of Engineering

Electrical & Electronic Engineering Department

LPF

EE463 Final Exam- Time: 2 hr Spring 2019 25/9/2019

Q1) a-What is the meaning of single ended signal, differential signaland give example.

b- What is sample and what is hold and when we use them. [6 pts]

0.39

Q2) Using Temperature sensor (RTD-PT100),in the range (30C to 90C) and using Wheatstone bridge (Vs=9V, R1=110, R2=120),and using voltage to frequency converter VFC (scale factor= 10KHz/1.12V) .

a- Calculate the sensor output range, Wheatstone bridge output range and VFC output range.

b- Using a counter to convert to digital with sampling rate 180 sample/Sec,What is the output range of the counter, what is the value of the output of the counter if the temperature is ~~150~~C . 55C°

c- Draw Block diagram of the circuit. [16 pts]

Q3) An accelerometer sensor sensitivity is 0.145mA/ g , used for measuring pressure in the range (± 20 g). and the value of its output @ 0 g is 5.2mA, using 190 Ω converting to volt resistance ,Design signal condition circuits for bipolar (8 bit) ADC with voltage reference ±4V.

a) Calculate sensor output range (current,voltage,Binary). $= \frac{\text{input} + V_{ref}}{\Delta V}$

b) What is the digital output of ADC at the acceleration is 8 g.

c) What is the value of acceleration when the digital output is 0DH,92H. [15 pts]

d) If the frequency of the signal is 120Hz and there is unwanted noise with frequency 15KHz, design filter that attenuate the noise to 18% of its value, calculate the effect on the sensor output range. [05 pts]

Q4) Using RTD with the following table using Quadratic approximation of resistance versus temperature find the value of the RTD at 12.4°C.

Temperature (°C)	0	5	10	15	20
Resistance (Ω)	103.6	105.1	106.3	107.1	108.3
190	103.6	105.1	106.3	107.1	108.3

[08 pts]

Good Luck (Zeyad)

| Final Exam   SPring 2019   أجوبة 4 نماذج امتحانات

Q(2) RTD-PT 100 , $(30^{\circ} \sim 90^{\circ} c)$, wheatstone bridge $\begin{pmatrix} V_s = 9V, & R_1 = 110\,\Omega \\ & R_2 = 120\,\Omega \end{pmatrix}$

VFC (10 KHZ / 1.12V)

$\left((30 \times 0.39) + 100\,\Omega \sim (90 \times 0.39 \frac{\Omega}{c^{\circ}}) + 100 \right) \Rightarrow (111.7\,\Omega \sim 135.1)$ Sensor o/P

- $R_1 R_4 = R_2 R_3 \Rightarrow 110 * 111.7 = 120 * R_3 \Rightarrow R_3 = 102.39$
- $V_a = 9 \times \frac{102.39}{102.39 + 110} = 4.339\,V$, $V_{b_1} = 9 \times \frac{111.7\,\Omega}{111.7 + 120} = 4.339$

$Vb_2 = 9 \times \frac{135.1}{135.1 + 120} = 4.766\,V$, $V_{b_1} - V_a = 0\,V$

$V_{b_2} - V_a = 0.427\,V$

- Wheatstone bridge o/P Range (0 ~ 0.427 V)
- VFC o/P Range (0 ~ 3.8125 KHZ)
- Counter o/P " $(\frac{1}{180}$ sec$) \Rightarrow$ (0 ~ 21.18 Pulse)

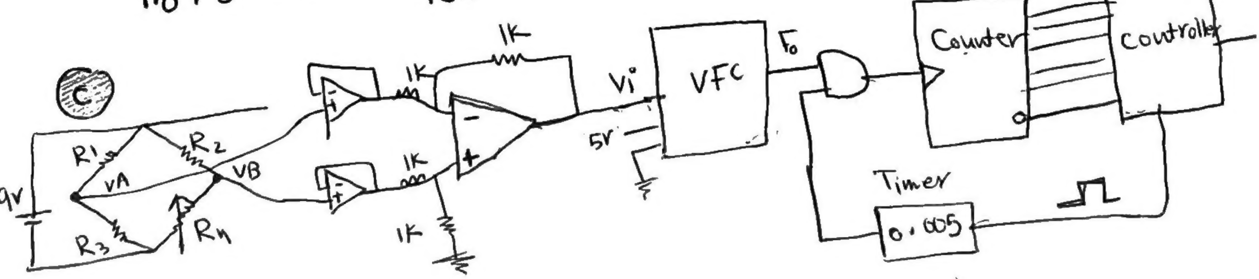
(b) $T = 55^{\circ} \longrightarrow$ Counter o/P $\Rightarrow$!?

$(55 \times 0.39) + 100 = 121.45\,\Omega \Rightarrow Vb = 9 \times \frac{121.45}{121.45 + 120} = 4.527$

$Vb - Va = 0.188\,V \Rightarrow 0.188 \times \frac{10KHZ}{1.12\,V} = 1.678\,KHZ$

$1.678\,KHZ \times \frac{1}{180}$ sec $= 9.32$ Pulse #

(c)



Q(3) 0.14 mA/g $(\pm 20g)$ @ 0g = 5.2 mA

R = 190 Ω (8 bit) ADC ±4 V reference

(a)

$((-20 \times 0.14) + 5.2) \sim ((20 \times 0.14) + 5.2) \Rightarrow (2.4 \sim 8\,mA)$ sensor O/P

$\boxed{(0.456\,V \sim 1.52\,V) \text{ Range in Volt}}$, $(142 \sim 176)$ Digital O/P

$\Delta V = \dfrac{8}{2^8} = 0.03125$, Digital O/P = $\dfrac{\text{analog I/P} + 4}{\Delta V}$

$(10001110 \sim 10110000)$ O/P Range in binary

(b) Digital O/P for 8g

$(8 \times 0.14) + 5.2 = 6.32\,mA \rightsquigarrow 6.32 \times 190 = 1.2\,V$

$(1.2 + 4)/0.03125 = 166 \rightsquigarrow (10100110)_2$

(c) accelaration value if O/P (0D, 92)

$(00001101)_2$, $(10010010)_2$

$\Downarrow$ $\Downarrow$

$(13)_{10}$ $(146)_{10}$

	1	2
analog I/P =	-3.594 V,	0.5625 V
in mA =	out of Range,	2.9 mA
accelaration =	,	-16.42 g

(d) $F_s = 120$ HZ , $F_N = 15$ KHZ , attenuate Noise 18%.

$$18\% = \frac{1}{\sqrt{1 + \left(\frac{15\,KHZ}{F_c}\right)^2}} \Rightarrow F_c = 2745\,HZ$$

$$\text{effect on The O/P} = \frac{1}{\sqrt{1 + \left(\frac{120}{2745}\right)^2}} = 99.9\%$$ very Good

"Low Pass filter"

Q(4)

°C	0	5	10	15	20
Ω	103.6	105.1	106.3	107.1	108.3
	①		⓪		②

$T = 12.4°C$

$$R(T) = R(T_0)\left(1 + \alpha \Delta T + \alpha_2 \Delta T^2\right)$$

$$108.3 = (106.3)\left(1 + 2.211 \times 10^{-3}(10) + \alpha_2 (10)^2\right)$$

$$\alpha_2 = -3.295 \times 10^{-5}$$

$$\alpha = \frac{1}{R(T_0)} \times \frac{R_2 - R_1}{T_2 - T_1}$$

$$= \frac{1}{106.3} \times \frac{108.3 - 103.6}{20 - 0}$$

$$= 2.211 \times 10^{-3}$$

$T = 12.4°C \rightarrow \Delta T = 2.4$

$$R(T) = 106.3\left(1 + 2.211 \times 10^{-3} \times 2.4 - 3.295 \times 10^{-5} \times (2.4)^2\right)$$

$$R(T) = 106.84\ \Omega$$:)

Final Fall - 2018

Q(1) RTD-PT100 (22 ~ 190°C) → (0 ~ 3V), ADC, Voltage Divider

$V_s = 9V$, $R_1 = 200$

(a) $((22 \times 0.39) + 100) \sim ((190 \times 0.39) + 100) \Rightarrow (108.58 \sim 174.1\ \Omega)$

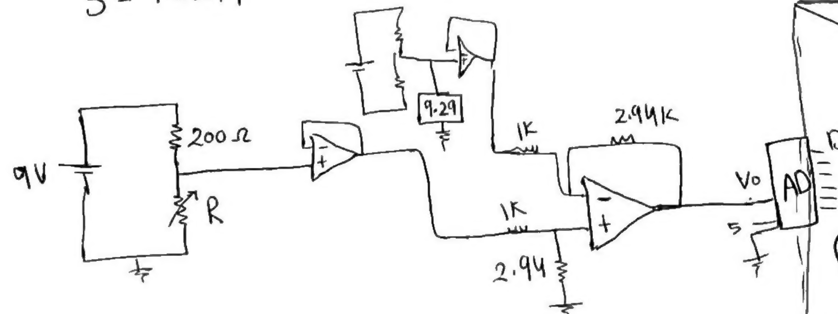
$$V_1 = 9 \times \frac{108.58}{108.58 + 200} = 3.16, \quad V_2 = 9 \times \frac{174.1}{174.1 + 200} = 4.18, \quad (3.16 \sim 4.18\ V)$$

$0 = 3.16M + \text{offset}$

$3 = 4.18M + \text{offset}$

$3 = 1.02M$

$\Rightarrow M = 2.94$, offset $= -9.29$ $\Rightarrow$ $[V_o = 2.94V_i - 9.29]$



$$\Delta V = \frac{3}{2^8} = 0.0117$$

$$\text{Digital o/P} = \frac{\text{analog I/P}}{0.0117}$$

[illegible]

$(0 \sim 256)_{10}$

③

(c) 100°C

$(100 \times 0.39) + 100 = 139\,\Omega \Rightarrow 9 \times \frac{139}{139 + 200} = 3.69\,V$

$V_o = 2.94 \times 3.69 - 9.29 = 1.5586\,V$ # , Digital O/P = 133

في حاجة مش مضبوطة في "..." ؟! لكن الأرقام صح عادي

Q(2) $S = 0.14\,mA/g$, @ $0g = 7mA$ $(\pm 30g)$, VFC $(4V/6KHz)$

(b)

$(-30 \times 0.14) + 7 = 2.8\,mA$, $(30 \times 0.14) + 7 = 11.2\,mA$, $(2.8 \sim 11.2\,mA)$

$R = 100\,\Omega \rightarrow (0.28\,V \sim 1.12\,V)$

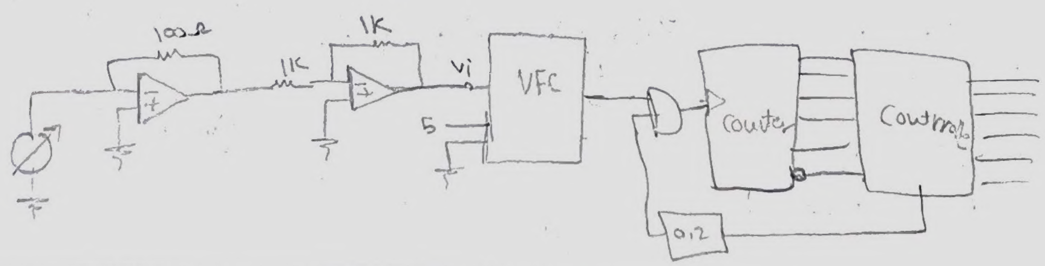
$\frac{1}{4/6} \frac{KHz}{V} \rightarrow (0.42\,KHz \sim 1.68\,KHz)$

$T = 0.2$ sec $\rightarrow$ (84 ~ 336 Pulse) $\rightarrow (01010100, 101010000)_2$

(c) $(-0.5g) \rightarrow (-0.5 \times 0.14) + 7 = 6.93\,mA \times 100\,\Omega = 0.693\,V$

$\rightarrow 1.0395\,KHz \times 0.2$ sec $= 208$ Pulse $\rightarrow (11010000)_2$

(d)



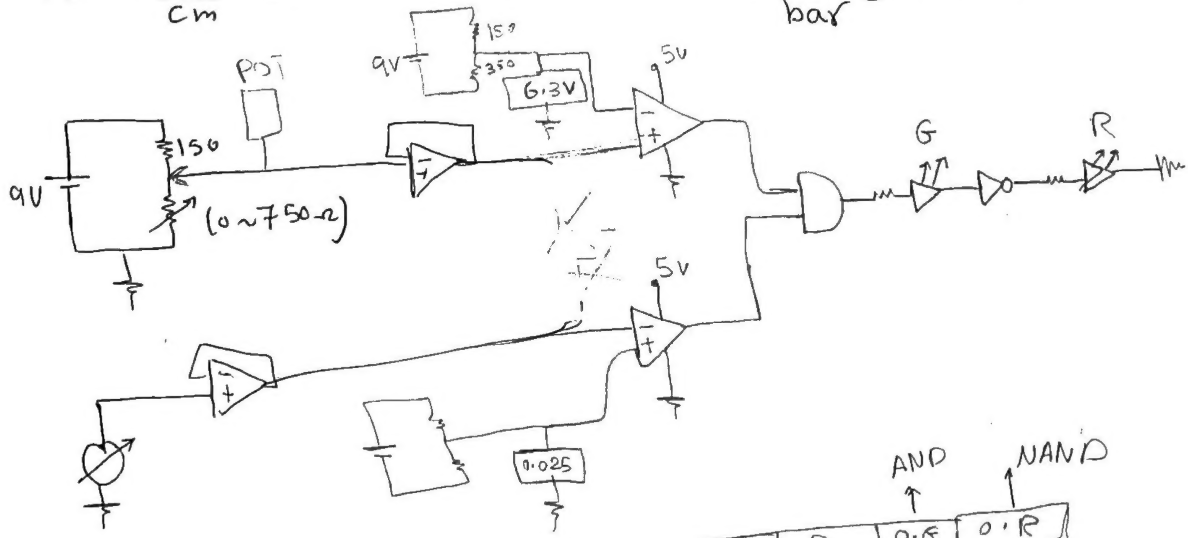
Q(3) $S = 5\,mV/bar$, $5\,\Omega/cm$ POT , 150 cm

$(V_s = 9V, R_1 = 150\,\Omega)$ Green $L > 70\,cm$

$P < 5\,bar$

ك وحدة متر ref

$150 \times \frac{5\Omega}{cm} = 750\Omega$, $5bar \times 5\frac{mv}{bar} = 25mV$



		AND ↑	NAND ↑
A	B	0.G	0.R
0	0	0	X
0	1	0	1
1	0	0	1
1	1	1	0

Q(4) قيم مش واضحة

Q(5) $V = 19mV$ $T = ?$, $T = -40°$ $V = ?!$ K_Type

$V = -1.50 mV$ #

$V_L = 18.94$, $V_H = 19.15$

$T_L = 460$, $T_H = 465$

$V_m = V_L + \left(\frac{V_H - V_L}{T_H - T_L}\right)(T_m - T_L) \Rightarrow 19 = 18.94 + \left(\frac{19.15 - 18.94}{5}\right)(T_m - 46?)$

$T_m = 461.43°$

Final spring 2018

Q(2) $S = 5mV/C°$, $(30 \sim 120°C)$, VFC (2V/1KHZ)

sensor o/p Range $(30 \times 5 \sim 120 \times 5) \rightarrow (0.15 \sim 0.6V)$

VFC o/p Range $\left(0.15 \times \frac{1}{2/1} \sim 0.6 \times \frac{1}{2}\right) \rightarrow (75 \sim 300 HZ)$

Coute o/p Range $\left(75 \times \frac{1}{10} \sim 300 \times \frac{1}{10}\right) \rightarrow (7.5 \sim 30 \text{ pulse})$

$T = 112^\circ c \rightarrow 112 \times 5 \frac{mv}{c} = 0.56\ V \rightsquigarrow 0.56v \times 0.5 \frac{KHZ}{V} = 0.2$

$280HZ \times \frac{1}{10} = 28$ Sample #

Q(3) $S = 0.13\,mA/bar$, $(-20 \sim +20 g)$, @ $\ominus$ bar $= 4\,mA$, $R = 150$

$\triangleq$ bar

ADC (8bit , $\pm 4V$ ref)

sensor o/p $(-20 \times 0.13) + 4 \sim (20 \times 0.13) + 4 \Rightarrow (1.4 \sim 6.6\ mA)$

$\Rightarrow (1.4 \times 150 \sim 6.6 \times 150) \rightsquigarrow (0.21 \sim 0.99\ V) \Rightarrow (135 \sim 160)$ Digital o/p

$\Delta V = \frac{8}{2^8} = 0.03125$ Digital o/P $= \frac{\text{analog I/P}}{0.03125}$

ⓐ $(P = 8\ bar) \Rightarrow (8 \times 0.13) + 4 = 5.04\ mA \times 150\,\Omega = 0.756\ V$

Digital o/P $= \frac{0.756 + 4}{0.03125} = (152)_{10} \rightarrow (10011000)_2$

128 64 32 16 8 4 2 1

ⓑ (Digital o/P = 18H) $\Rightarrow (18)_H = (00011000)_2 = (24)_{10}$

analog I/P $= (24 \times 0.03125) - 4 = -3.25\ V$ OUT OF RANGE

Q(4) "رحمة في الورقة"

$DAC = (0\ 1\ 0\ 1\ 0\ 1\ 0\ 1)_2$ (bits numbered 0 1 2 3 4 5 6 7) $\Rightarrow (85)_{10} \Rightarrow$ analog I/P (0.664) volt

$\Delta V = \frac{2}{2^8} = 7.8125 \times 10^{-3}$, Digital o/P $= \frac{\text{ang I/P}}{7.8125 \times 10^{-3}}$

$V_o = \left(\frac{R_f}{R} + 1\right) V_i = \left(\frac{1.7}{1} + 1\right) \times 0.664 = 1.7928\ V$ #

$\Delta V = \frac{5}{2^8} = 0.0195$, Digital o/P $= \frac{1.7928}{0.0195} = (92)_{10}$

$(01011100)_2$

Q(5) ref = 40°c   V = ? if T = 120°c   J- Type   (a)

$$V_{J40}(120) = V_{J0}(120) - V_{J0}(40)$$

$$6.\cancel{38} - 2.06 = 4.\cancel{37}\ mV$$

(b)

	①		⓪		②
C°	0	5	10	15	20
Ω	107.6	109.1	110.2	111.7	111.7

$\boxed{T = 11.4^\circ C}$

$$R(T) = R(T_0) * (1 + \alpha \Delta T + \alpha_2 \Delta T^2) \quad , \alpha = \frac{1}{R(T_0)} \cdot \frac{R_2 - R_1}{T_2 - T_1}$$

[redacted], ∴ Assume $R(T) = 111.7$.

$$\alpha = \frac{1}{110.2} \cdot \frac{111.7 - 107.6}{20}$$

$$111.7 = 110.2 \times (1 + 1.86 \times 10^{-3} \times 10 + \alpha_2 \times 100)$$

$$\alpha = 1.86 \times 10^{-3} \ \#$$

$$\alpha_2 = -4.98 \times 10^{-5}$$

$T = 11.4^\circ C \rightarrow$

$$R(T) = 110.2 \times (1 + 1.86 \times 10^{-3} \times (11.4 - 10) - 4.98 \times 10^{-5} (11.4 - 10)^2)$$

$$R(T) = 110.47^\circ C \ \#$$

Final Spring 2017

Q(1) $S = 4\ \Omega/^\circ C$ $(\pm 25^\circ C)$ @ $0^\circ C = 280\ \Omega$, Wheatstone Ω/V +use Transm

(8bit, 0~5v) ADC

$$((-25 \times 4) + 280 \sim (25 \times 4) + 280) \rightsquigarrow (180\ \Omega \sim 380\ \Omega)$$

$R_1 = 100$, $R_2 = 120$, $V_s = 9V$

$$R_1 R_4 = R_2 R_3$$

$$100 \times 180 = 120 \times R_3 \rightarrow R_3 = 150\ \Omega$$

$$V_a = 9 \times \frac{150}{150 + 100} = 5.4\ V, \quad V_{b1} = 9 \times \frac{180}{180 + 120} = 5.4\ V$$

$$V_{b2} = 9 \times \frac{380}{380 + 120} = 6.84V \rightarrow (0 \sim 1.44\ \text{Volt})$$

$V_o = V_i + 1$ using Transmitter $\rightarrow$ $(1 \sim 2.44\ \text{Volt})$

$\Delta V = \frac{5}{2^8} = 0.0195$, $(51 \sim 125)_{10} \rightarrow$ Digital O/P

$(00110011, \ 01111101)_2$

(a) $T = -2°C \rightarrow (-2 \times 4) + 280 = 272\ \Omega$

$V_b = 9 \times \frac{272}{272+120} = 6.24 \rightsquigarrow (6.24 - 5.4) = 0.844\ V + 1 = 1.844$

Digital O/P $= (94)_{10} \rightsquigarrow (01011110)_2$

Q(2) $S = 0.33\ mA/g$ $(\pm 20g)$ ADC (8bit , ∓ 4)

Sensor O/P $(-20 \times 0.33) \sim (20 \times 0.33) \Rightarrow (-6.6 \sim 6.6\ mA)$ Assume $R = 100\Omega$

$(-0.66 \sim 0.66\ V)$ [need Transmitter $(0.34 \sim 1.66\ V)$] → غير مطلوب

$\boxed{\Delta V = \frac{8}{2^8} = 0.03125}$, $(107 \sim 149)_{10} \rightarrow$ Digital O/P

(a) $(-3g) \rightarrow -3 \times 0.33 = -0.99\ mA \times 100 = -0.099\ V$

Digital O/P $\rightarrow (124)_{10} \rightarrow (01111100)_2$

(b) $(06\ H) \rightarrow (00000110)_2 \rightarrow (6)_{10}$ OUT OF RANGE

Q(3) (10 bit (0~5V)) ADC , Sensor O/P ($\pm 150mV$)

$F_s = 15\ Hz$, $V_N = 20mV$, $F_N = 150\ HZ$, attenuate (25%)

$\Delta V = \frac{5}{2^{10}} = 4.88 \times 10^{-3}$

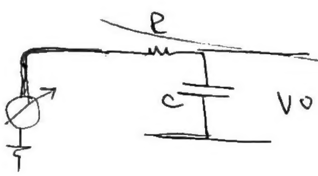
$25\% = \frac{1}{\sqrt{1 + \left(\frac{150}{F_c}\right)^2}} \Rightarrow F_c = 38.72\ HZ$

$V_o/V_i = \frac{1}{\sqrt{1 + \left(\frac{15}{38.72}\right)^2}} = 0.9324 \rightsquigarrow 93.2\%$ Good

$\gamma/0$ $(-150\,mV \sim 150\,mV) \xrightarrow{+20mV} (-0.13 \sim 0.17\,V)$

effect of filter in sensor o/p $(-0.13 \times 0.9324) \sim (0.17 \times 0.9324)$

$(-0.12 \sim 0.16V)$ #



$V_o = V_i + 1 \rightarrow (0.88 \sim 1.16V)$

Digital o/p $(180 \sim 237)_{10}$

$(00010100\,,\,0011101101)_2$

Q(4) Type-J

(a) $T = 32°c$ $V = \;?$

(b) $T > 32°c \rightarrow$ ON Cooler

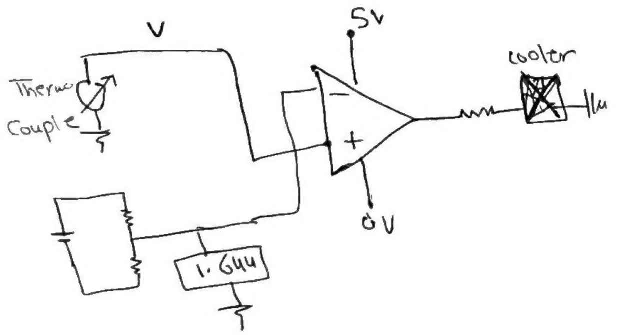
(a) $T_L = 30$, $V_L = 1.54$

$T_H = 35$, $V_H = 1.8$

$$T_m = T_L + \left(\frac{T_H - T_L}{V_H - V_L}\right)(V_m - V_L)$$

$$32 = 30 + \left(\frac{5}{0.26}\right)(V_m - 1.54)$$

$$V_m = 1.644 \;\#$$



(c) $T = 13°c \rightarrow \Omega = ?!$, $T < 13 \rightarrow$ ON heater

	1		2		
c°	0	5	10	15	20
Ω	107.6	109.1	110.2	111.3	111.7

$$\alpha = \frac{1}{R(T_0)} \times \frac{R_2 - R_1}{T_2 - T_1} = 1.86 \times 10^{-3}$$

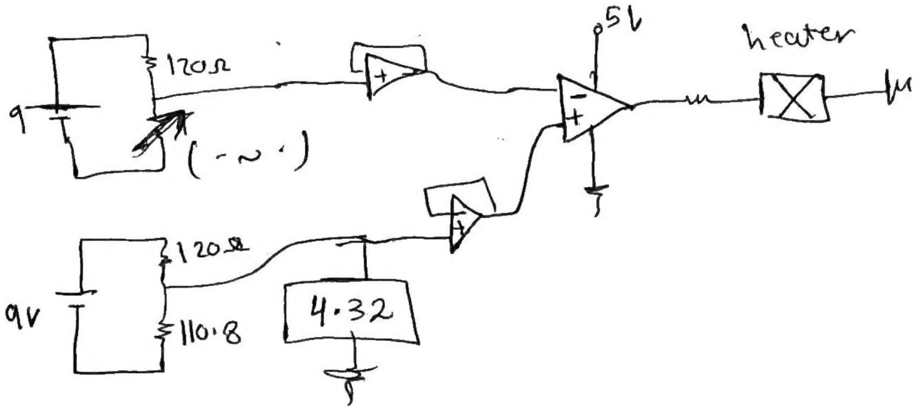
$$R(T) = R(T_0)(\alpha \Delta T + 1)$$

$$R(T) = 110.2\,(1 + 1.86 \times 10^{-3} \times 3)$$

$$R(T) = 110.8\,\Omega \;\#$$

$$V = 9 \times \frac{110.8}{110.8 + 120} = 4.32\,V \;\#$$

Assume R = 120 Ω , Vs = 9 V



Q(3) S-19 Final

(a) (0.456 V ~ 1.52 V)

$-4 = 0.456 M + F$ $\quad$ $M = 7.518$ $\quad$ $V_o = 7.518 V_i - 7.428$

$4 = 1.52 M + F$ $\quad$ $F = -7.428$

$8 = 1.064 M$

$(-4 \sim 4\ v)$

$\rightarrow (0 \sim 256)_{10}$

(b) $(89 \times 0.14) + 5.2 = 6.32\,mA \times 190\,\Omega = 1.2\,V \rightarrow 1.5936\,V$

Digital O/P $\approx (\cancel{6}78)_{10} \rightarrow (\cancel{0}0110\cancel{0}0)_2$

(c) $0D \rightarrow 13$, $92 \rightarrow 146$

$D_o \times \Delta V \doteq -3.59$, 0.5625

$V_o = V_i M + F = 0.51\ V$, $1.6628\ V$

$V/R = I = 2.68\,mA$, $5.59\,mA$

$g = -18\ g$, $2.79\ g$

Q(3) S-18 final

(0.21 ~ 0.99) v ,

$-4 = 0.21 M + F$ $\quad$ $M = 10.25$

$4 = 0.99 M + f$ $\quad$ $F = -6.15$

$8 = 0.78 M$

$V_o = 10.25 V_i - 6.15$

(a) $(8 \times 0.13) + 4 = 5.04\,mA \times 150\,\Omega = 0.756\,V \rightarrow$ ~~2.27~~ V 1.599

$(179)_{10} \rightarrow (10110011)_2$

(b) $(18)_H \rightarrow (24)_{10} \rightarrow -3.25\,V \rightarrow 0.28\,V \rightarrow 1.88\,mA$

$(-\cancel{1}6\ .25)\,g$